PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:
B21B 1/46, 1/24, C21D 8/02	A1	WO 92/00815
		(43) International Publication Date: 23 January 1992 (23.01.92)

(21) International Application Number: PCT/IT91/00057

(22) International Filing Date: 5 July 1991 (05.07.91)

(30) Priority data:
20884 A/90 9 July 1990 (09.07.90) IT

(71)(72) Applicant and Inventor: ARVEDI, Giovanni [IT/IT]; Via Mercatello, 26, I-26100 Cremona (IT).

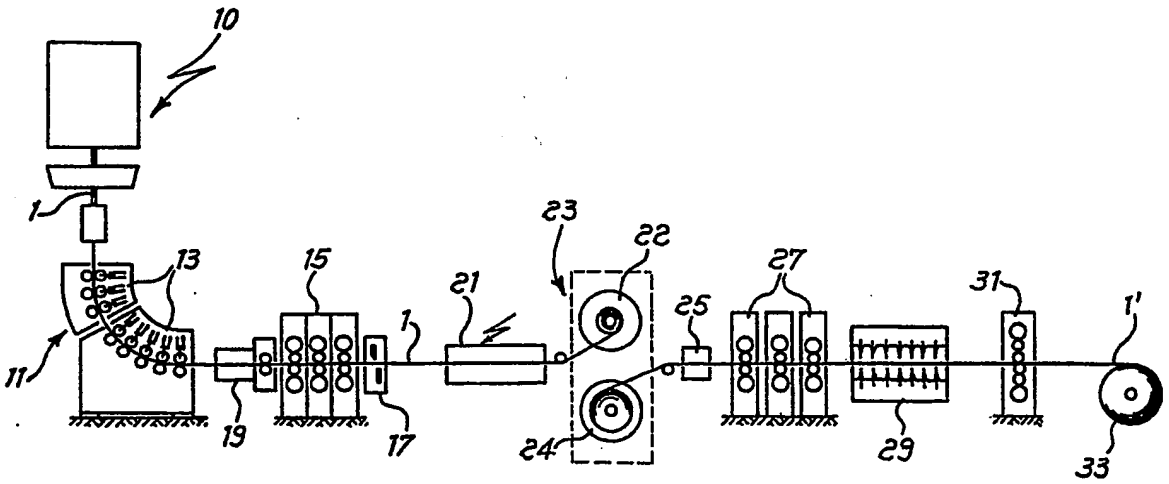
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : GOSIO, Giovanni [IT/IT]; Via F. Cavallotti, 15, I-26100 Cremona (IT).

(74) Agents: ADORNO, Silvano; Società Italiana Brevetti, Via Carduci, 8, I-20123 Milano (IT) et al.

(81) Designated States: AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH (European patent), CI (OAPI patent), CM (OAPI patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, RO, SD, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US. +

Published
With international search report.

(54) Title: PROCESS AND PLANT FOR OBTAINING STEEL STRIP COILS HAVING COLD-ROLLED CHARACTERISTICS AND DIRECTLY OBTAINED IN A HOT-ROLLING LINE



(57) Abstract

A process for obtaining steel strip coils with characteristics of a cold-rolled product, directly in a hot-rolling line, comprises subsequently to steps of casting and thickness reduction at a temperature of more than 1100 °C upon solidification, induction heating of the product and a further step of hot rolling, above point Ar_3, a step of cooling and temperature control in a range of between 600 and 250 °C, thus lower than said point Ar_3, as well as one or more passes of cold-rolling in series, with final coiling of the obtained product. Also a preferred plant is described for putting into practice such a process.

+ See back of page

+ DESIGNATIONS OF "SU"

It is under examination in which parts of the former Soviet Union the designation of the Soviet Union has effect.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland			SN	Senegal
CI	Côte d'Ivoire	KR	Republic of Korea	SU	Soviet Union
CM	Cameroon	LI	Liechtenstein	TD	Chad
CS	Czechoslovakia	LK	Sri Lanka	TG	Togo
DE	Germany	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		

"PROCESS AND PLANT FOR OBTAINING STEEL STRIP COILS HAVING COLD-ROLLED CHARACTERISTICS AND DIRECTLY OBTAINED IN A HOT-ROLLING LINE"

The present invention relates to a process and relevant plant for producing coils of steel strips, having characteristics of a cold-rolled product and directly obtained in a hot-rolling line from a continuous casting with arc-shaped path and horizontal outlet.

It is known that for obtaining hot-rolled steel strip coils, the following operations are provided, successively:

- producing by casting a steel slab having a thickness of between 160 and 250 mm, and possibly storing the same;
- heating such a slab, if coming from the store, or in any case bringing it again to a rolling temperature fo at least 1050°C;
- hot-rolling the slab for a first cogging and thereafter for obtaining hot-rolled strips having a minimum thickness of 2 mm;
- taking again the hot-rolled strip and subjecting the same to annealing for a reconstruction of the grain which has been deformed and become dishomogeneous during the preceding operations, in particular hot-rolling step;
- subjecting the product to pickling in order to eliminate from its surface the oxides previously formed, especiall during

annealing; and

- causing the actual cold-rolling step to be performed, which comprises mounting the coil onto an unwinding reel to bring again the strip onto a plane, causing the strip to pass through at least one cold-rolling stand until obtaining thicknesses of less than 1 mm, down to 0.5-0.2 mm and finally winding the strip on a reel to obtain the final coil.

It will be noted that the number of passes in the stands for cold-rolling depends on the desired final thickness and the reduction percentage which is to be obtained, in other words the ratio between thickness of the hot-rolled strip and thickness of the final product. For high values of such a percentage reduction it is not enough to increase the number of said passes, but it will be necessary to subject the strip to another annealing operation and the consequent pickling, otherwise the material hardens and the final product results to be of low quality.

Although it is possible to obtain by hot-rolling strips having a thickness of less than 2 mm, it is usually avoided to reach these values, as this type of processing is considered anti-economical, above all due to the reduced productivity that would be

obtained in this case with a conventional rolling mill. The costs relating to the reduction of strip thickness are however extremely high in any case. Assuming 100 the cost of hot-rolling, starting from liquid steel, the cost of cold-rolling step alone is of at least 80.

Attemps have been described as to making plants for obtaining thin strips by means of more compact operating cycles with respect to the above-mentioned conventional cycle, in order to reduce complexity and duration of the latter. For example EP-A-226446 describes a number of hot-rolling examples, all in line and at a very high speed (not less than 1500 mm/min) but the final product not only has a thickness of 2-6 mm, falling thereby in the range of hot-rolling, but also certainly does not show the structural features of a cold-rolled product. The main purpose of this published application is in fact restricted to a high productivity while obtaining at the same time a product of good processability, but not of high quality.

In EP-370 575 there is described a method for the manufacture of a steel strip having a final thickness of between 0.5 and 1.5 mm, comprising the steps of hot-rolling a steel slab of less than 100 mm thickness, at a temperature of between 300°C and

a temperature at which at least 75% of the material is converted into ferrite, with a thickness reduction of over 30% in at least one reduction stage, and an exit speed after hot-rolling of less than 1000 m/min, with final coiling of the strip after recrystallization. This was an attempt to avoid the two successive cycles of hot- and cold-rolling, with intermediate stages of annealing and pickling, but also this attempt has been unsuccessful, and it could not find success indeed, apart from the proposed solution, as in any case the inner structure of the material, when subjected to cold-rolling, is unsuitable to undergo this treatment for obtaining a final product of acceptable quality. This occurs owing to the fact that the inner structure, if not recrystallized before cold-rolling, results to be dishomogenous under a dimensional aspect and with insufficiently fine grains, in comparison with the grain size which would be required by the conventional cold-rolling technology according to the above-described cycle.

It is known on the other hand that an eccessive reduction of thickness with successive rolling stands on the same hot-rolling line gives rise to such a temperature decrease to go below the recrystalliza-

tion point Ar_3, at which the steel is no longer austenitic, whereby a subsequent annealing above Ar_3 restores the pre-existing structural situation without the benefits of grain reduction.

Instead it has been surprisingly found that the product obtained through the hot-rolling process according to the published international patent application WO 89/11363 for the continuous production of steel strip or plates from flat products through continuous casting with arc-shaped path and horizontal outlet, shows an inner structure with fine grains, so uniformely distributed to have already the characteristics of a material suitable to be cold-rolled. Therefore it has been thought that rolling up to thicknesses of less than 1 mm can be obtained with no need of annealing and pickling, as it can be in practice performed in line with the hot-rolling carried out upstream.

In this way a technical prejudice can be overcome, which is extremely common and deep-rooted both among those skilled in hot-rolling, and those, normally distinct therefrom, who are skilled in cold-rolling, since the material obtained in the hot-rolling line results to be suitable to cold-rolling, even if its temperature is caused to be lower than recrystal-

lization point Ar_3.

Therefore it is an object of the present invention to provide a process and relevant plant for obtaining a cold-rolled product, of extremely thin thickness, directly starting from the hot-rolled product, being coupled thereto as to the speed and with no need of further treatment (such as annealing and pickling) on the material, thereby without any discontinuity in the manufacturing line.

This is obtained by means of a process comprising the steps of casting in a mould at a thickness of less than 100 mm, preliminary reducing the thickness in a condition of liquid core of the casting product immediately under the mould, with further thickness reduction after solidification of casting in a first rolling stage until values of 10-30 mm at temperatures higher than 1100°C, induction re-heating up to a temperature as homogeneous as possible of about 1100°C and causing the flat product to pass through at least a further hot-rolling stage, above point Ar_3, characterized by the fact of comprising subsequently the steps of controlling the temperature at the outlet of hot-rolling stage to prefixable values in a range between 600 and 250°C, thus lower than point Ar_3, and one or more stages in series of cold-

-rolling with final coiling of the strip-shaped product obtained.

The plant for carrying out such a process will consist essentially of the plant described and claimed in the above-mentioned PCT patent application until exit of the last hot-rolling stand, being further characterized by a cooling and temperature controlling device, by one or more cold-rolling stands and a final strip coiler.

It should be appreciated that the expected temperature at the outlet from the controlled cooling device is always less than that of recrystallization point Ar_3, which varies according to the carbon content in the steel, with a minimum of 690°C for 0.6% of carbon, up to a maximum of 900°C for lower or higher carbon contents. Therefore it is certain that the subsequent processing is actually a cold-rolling step, which is carried out on a material the inner structure of which has all the required characteristics in order that the cold-rolling operation is accomplished in the best way and the final product is provided, from a metallurgical point of view, with all the properties which are required to a cold-rolled product.

These and further objects, advantages and features

of the process according to the present invention, as well as of the relevant plant, will be clear to those skilled in the art from the following detailed description of a preferred embodiment, given by way of a non-limiting example with reference to the annexed drawing showing a diagrammatic view of a plant according to the invention, useful to describe also the process of the invention.

From a continuous casting mould 10, the steel flat product 1, driven and guided by a known-type roller path being arc-shaped, from an initially vertical direction, passes through the arc-shaped path formed by the rollers 11, to a horizontal direction. The thickness of the casting product 1 is firstly reduced in a condition of liquid core, for example in two distinct sections of rollers 13 and thereafter, upon solidification, but still at a temperature of about 1100°C, in a first stage of rolling 15 at the end of the bent path 11 and at the beginning of the horizontal path. Subsequently, in an induction oven 21 the flat product 1 is re--heated to bring it again to hot-rolling temperature, and then rolled in one or more rolling stands 27, between which there may be possibly provided additional induction ovens (not shown in the drawing)

for maintaining the rolling temperature of at least 865°C at the outlet from the stand.

According to an embodiment of this first portion of the plant, substantially already known from WO 89/11363, immediately after the first rolling stage 15 there may be provided a shear 17 and before said stage 15 a discaling device 19 for eliminating scale from the surface of the product to be treated. Furthermore, between the induction oven 21 and the hot-rolling stands 27 there may be provided a winding and unwinding device 23 comprising a reel 22 for coiling the strip from oven 21, being coupled to a reel 24 for uncoiling the strip itself to be fed to stands 27, possibly after an additional discaling step in a suitable device 25 provided at the inlet of the first rolling stand.

According to the present invention, the hot-rolled strip 1, at the outlet of the last rolling stand 27 at a temperature certainly higher than the recrystallization point Ar_3, is caused to enter, still in the same production line, a cooling and temperature controlling apparatus 29, at the exit of which the strip has a temperature, controllable at each time, comprised in a range of between 250 and 600°C. It substantially consists of a water-

-based cooling device, for example of the so-called "laminar rain" type, being provided with a temperature detector with a feed-back controlling the valves for feeding water into the device. The value of temperature to be fixed for strip 1 at the inlet of the subsequent cold-rolling stage, with deviations of not more than 20°C, will depend on the type of steel (carbon content, etc.), the feeding speed of the strip and its thickness, but in any case it will be less than the temperature at the recrystallization point Ar_3, which varies between 900°C and a minimum of 690°C for a carbon content of 0.6%. As the maximum temperature provided at the outlet of apparatus 29, thereby at the inlet of subsequent cold-rolling stage 31, is of 600°C, the strip is surely under the point Ar_3, and thus at the best conditions to undergo the cold-rolling step, due to the fine grain structure of the material from the upstream treatment, absolutely suitable to be subjected to cold-rolling.

Such a rolling occurs in at least one stand, for example of "six high" type, i.e. with six rolls mounted in vertical. The passes of cold-rolling may however be more than one, but all in series when providing a multiplicity of stands side by side,

contrary to the method of providing for a multiplicity of subsequent passes in the same stands, as according to the conventional technology of cold--rolling.

Finally the cold-rolled strip, with a thickness of less than 1 mm, ready for use as it shows the tipical microcrystalline features of a cold-rolled product, such as a homogeneous distribution of grains, is wound on a final coiler 33. The lower limit of the thickness that can be obtained in this way will be only dictated by the nip of the cold-rolling stands 31, as well as their precision, not certainly by problems of material hardening or anyhow deriving from its metallurgical structure.

CLAIMS

1. A process for obtaining steel strip coils, having characteristics of cold-rolled product, being directly obtained in hot-rolling line, comprising the steps of:

a) mould casting at a thickness of less than 100 mm;

b) preliminary reduction of the thickness in a situation of liquid core of the casting product immediately under the mould;

c) further reduction of thickness upon solidification of casting in a first stage of rolling at temperatures higher than 1100°C until values of 10-30 mm;

d) induction re-heating up to a temperature as homogeneous as possible of about 1100°C;

e) subjecting the flat product a further stage of hot-rolling,

characterized by the fact of comprising subsequently the steps of bringing the temperature of the product from the hot-rolling stage, still above point Ar_3, to prefixable values lower than said point Ar_3, preferably in the range between 600 and 250°C; and one or more cold-rolling passes in series, with final coiling of the strip-shaped product obtained.

2. A process according to claim 1, further comprising one or more of the following steps:

i) coiling and subsequent uncoiling of the strip immediately after the induction heating, upon cutting the strip immediately after the first rolling stage;

ii) at least one discaling step;

iii) additional heating between two further stages of hot-rolling;

3. A plant for obtaining steel strip coils, having characteristics of cold-rolled product, directly obtained in a hot-rolling line, comprising:

a) a mould (10) for continuous casting of flat products (1) with a subsequent arc-shaped guide roller path (11);

b) a first reduction device (13, 15) for reducing thickness of the flat product in the curve path in a condition of liquid core and/or immediately thereafter upon solidification of product (1);

c) a device (21) for induction heating and homogeneization of temperature along the cross-section of the flat product (1);

d) at least one additional rolling stand (27),

characterized by further comprising, immediately downstream of the last hot-rolling stand (27) an

apparatus (29) for cooling and controlling the temperature of product (1) until under point Ar_3, one or more cold-rolling stands (31) and a final coiler (33) for winding the strip in a coil (1').

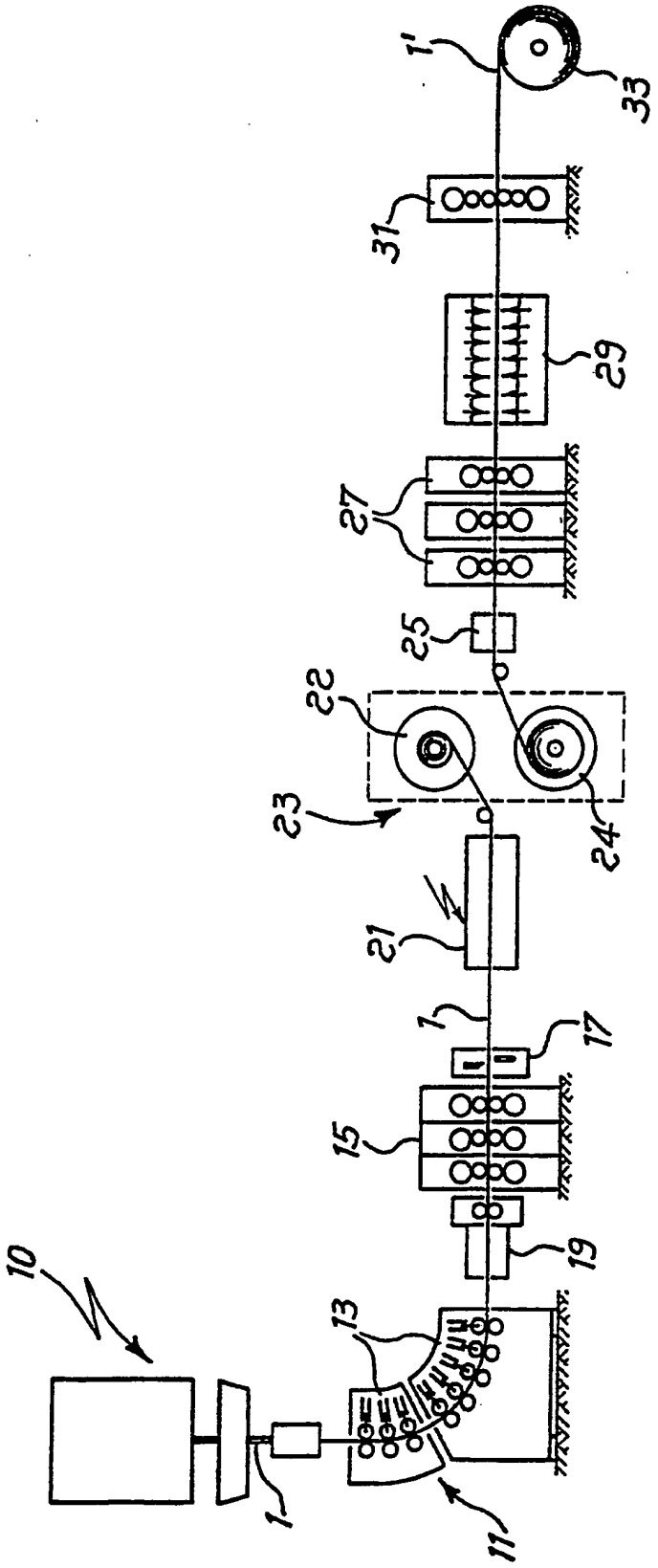
4. A plant according to claim 3, characterized in that said cooling apparatus (29) is a water cooling device provided with a temperature detector with feed-back for automatic controlling of the cooling water feeding valves.

5. A plant according to claim 3 or 4, characterized in that the range of variation of the temperatures at the exit of said device (29) is between 250 and 600°C, with a deviation of more or less 10°C from the prefixed value at the inside of said range according to the quality of steel, the feeding speed and the product (1) thickness.

6. A plant according to any of claims 3-5 further comprising a device (23) for winding and subsequently unwinding the strip immediately downstream of the induction oven (21), upstream of the latter there being provided a shear cutting device (17).

7. A plant according to any of claims 3-6, further comprising at least a discaling device (19, 25), respectively upstream of the first rolling stage (15) and downstream of said induction oven (21).

8. A plant according to any of claims 3-7, further comprising at least an additional induction oven intermediate between two subsequent rolling stands (27).


1'
33
31
29
27
25
22
23
24
21
1
17
15
19
10
13
1
11

INTERNATIONAL SEARCH REPORT

International Application No PCT/IT 91/00057

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.5 B 21 B 1/46 B 21 B 1/24 C 21 D 8/02

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl.5	B 21 B C 21 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[10]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	EP,A,0306076 (HOOGOVENS GROEP) 8 March 1989, see claims 1,13-19; figures	1,3,4,7
A	---	2,5,6
Y	WO,A,8911363 (MANNESMANN et al.) 30 November 1989, see the whole document (cited in the application)	1-8

Y	Sheet Metal Industries, vol. 50, no. 5, May 1973, (Redhill, GB), T. Okamoto et al.: "Manufacture of deep-drawing sheet by warm rolling", pages 297-302, see page 297 - page 298; figure 1	1-8
	--- -/-	

[10] Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
09-10-1991	24. 10. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. PEIS

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
P,A	Steel Times International - Incorporating Iron & Steel International, vol. 14, no. 5, September 1990, (Redhill, Surrey, GB), "Thin end of wedge for minimill in Italy", pages 38-39, see the whole article	1-8
A	EP,A,0226446 (KAWASAKI STEEL) 24 June 1987, see columns 2,3,5-7,10-12; figures 11-14 (cited in the application)	1-4,6
A	EP,A,0370575 (HOOGOVENS GROEP) 30 May 1990, see page 6; figure 2 (cited in the application)	1-4,7
A	DE,A,1903554 (SUMITOMO METAL INDUSTRIES) 28 August 1969, see page 8; claims; figure	1,3,4
A	JP,A,56144805 (NIPPON KOKAN) 11 November 1981, see figures, & Patent Abstracts of Japan, vol. 6, no. 26 (M-112)[904], 16 February 1982	1-3,7

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. IT 9100057 SA 49299

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 17/10/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A- 0306076	08-03-89	NL-A-	8702050	03-04-89
		AU-A-	2177988	02-03-89
		JP-A-	1071505	16-03-89
		US-A-	4885041	05-12-89
		US-A-	5009396	23-04-91
WO-A- 8911363	30-11-89	AU-A-	3686289	12-12-89
		DE-A-	3840812	05-04-90
		EP-A-	0415987	13-03-91
EP-A- 0226446	24-06-87	JP-A-	62137103	20-06-87
		JP-A-	62137104	20-06-87
		JP-A-	62137105	20-06-87
		AU-B-	574941	14-07-88
		AU-A-	6644486	18-06-87
		CA-A-	1268402	01-05-90
		US-A-	4793401	27-12-88
		JP-A-	62230403	09-10-87
EP-A- 0370575	30-05-90	NL-A-	8802892	18-06-90
		AU-A-	4556089	31-05-90
		CA-A-	2003819	24-05-90
		JP-A-	2213414	24-08-90
		US-A-	5042564	27-08-91
DE-A- 1903554	28-08-69	FR-A-	2000642	12-09-69
		GB-A-	1247232	22-09-71
JP-A-56144805	11-11-81	None		